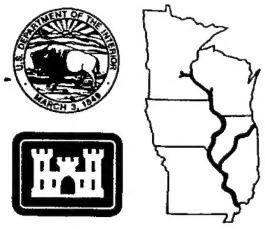

Long Term Resource Monitoring Program

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Mussel Resources of the Illinois River System—Value to Illinois' Economy and Natural Heritage

September 1998

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Mussel Resources of the Illinois River System—Value to Illinois' Economy and Natural Heritage

by

K. D. Blodgett, R. E. Sparks, S. D. Whitney, and R. Williamson

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Preface

This reprint originally appeared in *Proceedings of the 1997 Governor's Conference on the Management of the Illinois River System* and is being provided in this format as a service to Long Term Resource Monitoring Program (LTRMP) partners.

The LTRMP interests in the subject matter of this report are embodied in the LTRMP Operating Plan[1] in Strategy 2.2.7, *Monitor and Evaluate Selected Macroinvertebrate Populations and Communities*. This report was developed with partial funding provided by the Long Term Resource Monitoring Program.

The LTRMP is being implemented by the Environmental Management Technical Center, a U.S. Geological Survey science center, in cooperation with the five Upper Mississippi River System (UMRS) States of Illinois, Iowa, Minnesota, Missouri, and Wisconsin. The U.S. Army Corps of Engineers provides guidance and has overall Program responsibility. The mode of operation and respective roles of the agencies are outlined in a 1988 Memorandum of Agreement.

The UMRS encompasses the commercially navigable reaches of the Upper Mississippi River, as well as the Illinois River and navigable portions of the Kaskaskia, Black, St. Croix, and Minnesota Rivers. Congress has declared the UMRS to be both a nationally significant ecosystem and a nationally significant commercial navigation system. The mission of the LTRMP is to provide decision makers with information for maintaining the UMRS as a sustainable large river ecosystem given its multiple-use character. The long-term goals of the Program are to understand the system, determine resource trends and effects, develop management alternatives, manage information, and develop useful products.

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[1]U.S. Fish and Wildlife Service. 1993. Operating Plan for the Upper Mississippi River System Long Term Resource Monitoring Program. Environmental Management Technical Center, Onalaska, Wisconsin, Revised September 1993. EMTC 91-P002R. 179 pp. (NTIS #PB94-160199)

MUSSEL RESOURCES OF THE ILLINOIS RIVER SYSTEM - VALUE TO ILLINOIS' ECONOMY AND NATURAL HERITAGE

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INTRODUCTION

Through the ages, freshwater mussels have been utilized by a variety of peoples for a variety of purposes, most often for the raw materials they have provided. More recently we are beginning to appreciate these organisms for the services they provide in aquatic ecosystems. And increasingly we are using mussels as a source of valuable knowledge that will have direct application to maintaining and even improving our quality of life in the future. This paper reviews the history of our exploitation of native freshwater mussels, especially of the Illinois River, and then briefly discusses some of these newer values of our mussel resources.

EARLY USES OF MUSSELS

The fact that mussels were an important resource for native Americans in the Illinois River Valley can be gleaned from numerous archaeological digs throughout the valley. In addition to their worth as an important food source, native Americans used mussel shells for a variety of utensils, such as spoons, and as tools, especially hoes and scrapers. They were made into decorative ornaments such as pendants and were fashioned into fish lures or decoys.

As do their marine relatives, freshwater mussels sometimes produce pearls, and pearls have been treasured for several thousands of years. Early settlers and later loggers and trappers, also collected mussels for food, and while pearls are relatively rare, they were sometimes discovered. In the Midwest in the mid-1800s, single pearl finds often precipitated "pearl rushes" during which eager fortune seekers ravaged entire mussel beds, collecting every mussel they could get their hands (or feet) on, cutting them open and inspecting them for pearls, and then discarding the dying animals. Claassen (1994) reports that in the early 1900s, single pearls from the Wabash River sometimes sold for up to $4000 each (about $67 thousand in 1996 dollars) and that during a five-year period the Wabash River yielded more than $1 million worth of pearl; that was more profit than had been realized from the exploitation of other natural resources of the region such as zinc, gold, silver, gas, oil, and copper, and all public utility companies during the previous 10 years.

THE PEARL BUTTON INDUSTRY

According to Coker (1919), in 1872 a William Slater of Peoria, IL shipped some freshwater mussel shells to Europe; those shells were reportedly collected from the Illinois

River at Peoria. Apparently a box of those shells eventually ended up on the workbench in a button maker's shop in Germany. The shop's owner, John F. Boepple, found the strange shells known to him only as from a river "somewhere about 200 miles southwest of Chicago" were a raw material from which he could produce good quality, durable buttons. In March of 1887, Boepple immigrated to America and while staying with his sister in Petersburg, IL, he heard of a good supply of shells in the Rock Island area. He finally found just the right kind of shells in the Mississippi River near Muscatine, IA. In January of 1891, Boepple formed a partnership which has been labeled as the beginning of the freshwater pearl button industry (Claassen 1994). In 1894, 196,000 pounds of shells were harvested from the Mississippi River near Muscatine and at an average value of almost $0.015 per pound, the harvest was reportedly worth $2,700 (Bartenhagen 1976 in Claassen 1994); converted to 1996 dollars, that is equivalent to $0.23 per pound and a total worth of $45,000.

Initially, mussels usually were collected without specialized tools; harvesters entered the water and collected shells by hand (called hand picking) or with their feet (called toe-digging). These methods, collectively referred to as pollywogging, limited harvest to those areas where the water was shallow enough for collectors to swim to the bottom and probably protected deep-water beds from overharvest. Around 1897, the crowfoot or brail hook was developed. The hooks were attached to pipes or boards and dragged from boats across mussels beds. Some of these wire hooks slipped into the openings between the shells of mussels. The mussels closed, clamping down on the hook and being dislodged from the substrate, they then could be lifted to the surface. The brail bars, as they were called, allowed shellers (those collecting mussels) to harvest beds in deeper water. Coker (1919) reported that about 70% of the shells collected between 1912 and 1914 were taken by brail. Other tools used to harvest shells included forks, clam tongs, and dredges.

The shell button industry flourished. On a good bed, a sheller could earn $30 per week (about $500 in 1996 dollars) in 1898, and overall earnings averaged $10 per week (Claassen 1994). Coker (1919) reported 13 button factories along the Mississippi by 1897, and the number had grown to 49 in 1898. There were 16 or 17 button factories in Muscatine alone in 1899 (Claassen 1994). According to Scarpino (1985) an estimated 9,746 shellers worked the Mississippi River between 1912 and 1914.

While Danglade (1914) indicated there was some shelling done on the Illinois River in 1872 and 1892, it was in 1907 that shellers from the over-harvested Wabash River first focused considerable attention on the Illinois. Shelling that year was on the lower one-third of the river between Bath and Pearl. According to Coker (1919), in 1908 shell sales from the Illinois River amounted to $139,000 ($2.3 million in 1996 dollars) and accounted for 20% of all proceeds from musseling in the Mississippi Basin. The top price for shells was about $0.008 per pound ($20 per ton), so it is likely over 14 million pounds were sold.

Shelling peaked on the Illinois in 1909 when according to Danglade (1914) about 2,600 boats were shelling between Peru and Grafton; that was an average of more than 10 boats per mile. By 1912, Danglade had labeled the Illinois as the most productive mussel stream, per mile, in the North America. However, by that time the Illinois was already showing signs of overharvest, and only about 400 boats were working the river. Coker (1919) reported that in 1913, 11.8 million pounds of shells were sold from the Illinois River at a price of $88,797 ($1.4 million in 1996 dollars) and associated pearls sold for almost $40,000 ($633,246 in 1996 dollars).

Over the next several years the effects of overharvest coupled with negative impacts of pollution and habitat alterations (e.g., from dams) reduced the mussel populations in the Illinois River. While harvest fluctuated from year to year, by 1940 it had dropped below five million pounds annually (Figure 1). The use of plastics further reduced the market and harvest. However, about this time a new market for Midwestern mussel shells was developing.

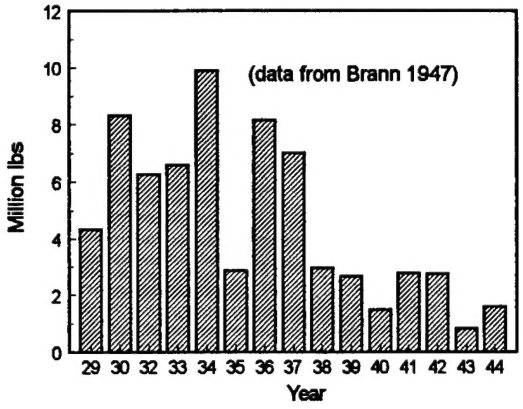

Figure 1. Mussel harvest from Illinois, 1929-1944.

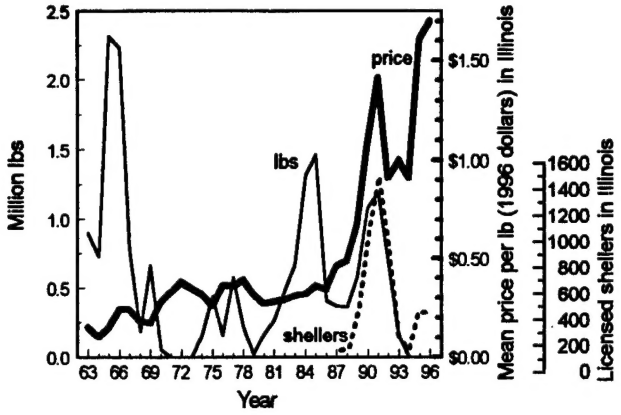

Figure 2. Mussel harvest from the Illinois River, 1963-1996.

CULTURED PEARL INDUSTRY

Japanese had been experimenting with pearl culture since the late 1800s. They had found freshwater mussel shells were an excellent raw material from which to produce cultured pearls. Significant shell export to Japan began in the late 1940s and early 1950s. In Japan the shells are sliced, the slices cut into cubes, and then the cubes are machined into spheres or nuclei. These nuclei are surgically implanted in marine oysters. The implanted oysters are maintained in bays, and during this culturing process, they lay down a layer of pearl over the outside of the shell nucleus. The longer the period of time over which the nucleus remains in the oyster, the thicker the layer of pearl over the mussel shell nucleus becomes. Originally, pearls were cultured for several years, but now they are more often cultured only several months; most cultured pearls produced today are more than 95% Midwestern mussel shell with only a thin layer of true pearl over the outside.

Today, the cultured pearl industry is big business. From 1990 through 1995, a total of nearly 100 million pounds of shells was exported to Japan from the United States (personal communication, Baker 1995 in Fassler 1997); the 19.8 million pounds exported in 1991 was reportedly worth $40 million (personal communication, Baker 1993). In the United States, retail sale of cultured pearl jewelry is estimated to be worth about $700-800 million per year and worldwide amounts to $3 billion annually (personal communication, Peggy Baker, president, Tennessee Shell Company, November 1993). Mussel harvest fluctuates dramatically and is dependant on many factors including price, shell availability, and river conditions; for example, fewer shells are usually collected during flood years. From the Illinois River, from 1963 through 1993, the reported harvest was 18.7 million pounds (9350 tons) or an annual average of almost 700 thousand pounds (Figure 2). In 1996 dollars, shellers have received a total of almost $8.5 million since 1963, an average of $300 thousand per year, for Illinois River shells.

Up through the early 1990s, the mean price per pound paid to shellers fluctuated less

dramatically than harvest and had increased somewhat faster than the cost of living (Figure 2). While license data prior to 1987 are not available, from 1988 through 1993 there was a positive relationship between average price per pound and both numbers of shellers (which may be used as an indication of effort) and harvest (Figure 2). When the mean price per pound paid to shellers more than doubled from 1987 through 1991, the number of shellers increased almost ten fold, from 173 shellers in 1987 to about 1500 in 1991. Harvest from the Illinois River increased over 200% from 369 thousand pounds in 1987 to 1.19 million pounds in 1991. In 1992, the mean price per pound dropped by one third; so did the number of licensed shellers and harvest dropped over 40%. Although prices stabilized in 1993, the number of shellers and the harvest continued to drop, probably due in part to the 1993 flood which made harvesting difficult. That same year, a dense infestation of zebra mussels in the Illinois River threatened native mussel populations, and the Illinois was closed to harvest in 1994. With the Illinois River closed, only the Mississippi River remained open for harvest in Illinois beginning in 1994. Average price rebounded to $1.56 per pound in 1995 and $1.70 per pound in 1996. However, neither the number of shellers nor the harvest in Illinois has re-bounded to the levels of a few years ago, and preliminary information indicates even lower numbers for the 1997 season.

CURRENT STATUS OF MUSSELS

Today, our North American mussels are one of the most endangered groups of organisms in the world. According to Williams et al. (1994) of the 297 taxa or kinds of native freshwater mussels described from North America, one-third are endangered, more than 14.5% are threatened, and 24% are of special concern. That means we know that at least 71% are either gone or in trouble. When you eliminate the ones we are not sure about, that leaves only 24% of our native mussel fauna that is considered stable.

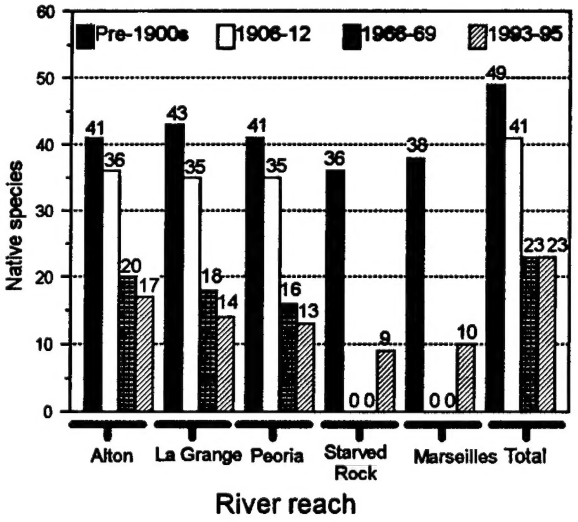

Figure 3. Mussel diversity in the Illinois River over time.

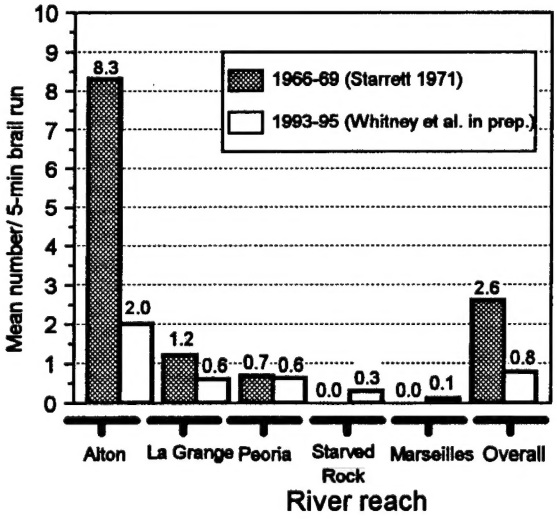

Figure 4. Mean catch rates for brail collections from the Illinois River, 1966-69 and 1993-95.

If we focus on the Illinois River, around the turn of the century several mussel surveys give us a reasonable idea of the mussel diversity (the kinds of mussels) once present in the Illinois River (i.e., Calkins 1874, Kelley 1899, Baker 1906, Forbes and Richardson 1913, Danglade 1914, and Richardson 1928). However, because their sampling methods were not quantitative, we do not have data on historical densities. Based on their reports and more recent analysis of museum records by Kevin Cummings of the Illinois Natural History Survey, we now believe there were 49 species of native freshwater mussels in the Illinois River at the turn of the century (Figure 3).

In his work on the Illinois River during the 1960s, Starrett (1971) found only 23 species (Figure 3). During our recent survey of the Illinois River from 1993 through 1995 (Whitney et al. in preparation), we also collected 23 species, but found diversity on the lower river has continued to decline. We were pleased to find mussels on two upper reaches of the river where Starrett collected none during the 1960s. However, during our recent survey, we used diving which is a more effective sampling technique than those employed by previous researchers. It is likely that had we employed only the less efficient collection methods used by previous researchers, our diversity would have been less. It is also noteworthy that four of the species we collected during our recent survey were represented by single specimens, and one other by only two individuals.

During our recent survey of the Illinois River, we also made collections with a brail bar, similar to what Starrett used in the 1960s, and we compared our catch-per-unit-effort (mussels collected per five-minute brail run) with Starrett's. Overall, our catch rate was about one-fifth that reported by Starrett 30 years ago, so it appears mussel densities have declined drastically (Figure 4).

ZEBRA MUSSELS

Recently, in addition to habitat alteration, pollution, and overharvest, native mussels are facing a new threat--the invading zebra mussel. The first zebra mussel reported in the Mississippi River drainage was collected from the Illinois River in June 1991 near Bath, approximately 60 miles downriver from Peoria. It was collected by a sheller and was attached to a native mussel. We deployed zebra mussel samplers at five sites along the lower 210 miles of the Illinois soon after the first find in 1991. When we retrieved those samplers in November 1991, the only one with zebra mussels was from our upriver site at Hennepin, and that sampler had only three zebra mussels on it (equal to less than 15 per square meter). Zebra mussel numbers on the Illinois increased dramatically in 1992; we collected them at all sites we monitored, and we documented densities as high as 650 per square meter at one site. In 1993, during the flood, the Illinois River experienced a zebra mussel population explosion which resulted in densities as high as 60,000 per square meter on the lower river. By the fall of 1993, we saw significant mortality of both zebra and native mussels, and native mussel mortality increased through 1994 and 1995. Since then, it appears zebra mussel numbers have not rebounded on the lower two-thirds of the river, but we believe the potential for additional dense infestations on the river is still high.

Zebra mussels produce microscopic larvae which drift in the water column. Since 1994, we have monitored zebra mussel larvae in the Illinois River mainstem at one site near Havana. In both 1994 and 1995, we documented densities well over 100 per liter, and when

we multiplied those densities by the discharge of the river, at times we estimated more than 60 million larvae were passing our sample site each second; we estimate about 200 trillion larvae passed Havana in both 1994 and 1995 (Stoeckel et al., 1997). We were pleased to see larvae numbers down during 1996, but they have rebounded somewhat in 1997. If environmental conditions are right, we could see adult zebra mussel densities similar to those we saw of 1993.

SERVICES MUSSELS PROVIDE

Ecosystem Services

Native mussels play several critical roles in aquatic ecosystems. For example, in rivers and streams, mussels can provide important stable substrates in a shifting, unstable environment. Aquatic insect eggs and larvae, and fish eggs attached to mussel shells are protected from being scoured away or from being buried by sand and silt, because mussels move up and down in the substrate to maintain their position at the substrate-water interface. Mussel beds also create structure and habitat diversity used by many fishes as nursery and feeding areas.

Mussels are filter feeders. They function as small water treatment plants by removing particulate organic matter (and its associated oxygen demand) from the water column. Basically they clean the water. These filter feeders then convert that organic matter into biomass (their flesh) which can be an important food source for some fish and wildlife (e.g., freshwater drum, catfish, muskrats, and raccoons).

Knowledge

Mussels provide knowledge, knowledge that can be used to maintain or even increase the quality of our aquatic ecosystems and even our lives. Understanding the ecological roles organisms play in ecosystems helps us discern the ways these complex systems function, how much stress they can take before they break, and how they sometimes repair themselves. Then this knowledge can be used to help us with risk assessments and predicting the ecological consequences of perturbations, both intentional and accidental, as well as rehabilitation efforts on the system. As an example, a better understanding of the filter-feeding roles of mussels (and other filter feeders) may assist us in determining the capacity of the Illinois River to assimilate organic matter from municipal wastes--how much could we improve water quality in the Illinois River by enhancing native mussel populations?

Mussels have been used in basic physiological research. They use tiny hairlike projections called cilia that beat like little paddles to create water currents to transport oxygen and food into their shells. These cilia also trap and transport food particles to the mussels' mouths. We too have cilia, among other places in our lungs, and one function of these cilia is to aid us in removing foreign particles from our lungs. Nervous control of these cilia is localized in humans just as it is in mussels, and some of the research to understand neural control of cilia in human lungs was carried out at the Southern Illinois University-Carbondale School of Medicine using native mussels collected from the Illinois River.

Biomedical research has also used mussels. Some degenerative diseases, such as Parkinson's disease, are due to problems with substances called neurotransmitters. Again at

SIU, basic research on the roles of neurotransmitters has been carried out using native mussels and their relatives the fingernail clams. Because filter feeding mussels are exposed to a host of disease-causing bacteria and viruses, they have developed impressive immune systems. Future studies of mussel immune systems could provide insights into the systems of other organisms including humans.

Often, structural designs used by living organisms in nature can be copied to provide new materials with improved properties--biomimetics. A mussel shell is composed primarily of calcium carbonate, but a complex layering of the calcium carbonate with organic substances produces a structure far stronger than that of calcium carbonate alone. A knowledge of the shell structure is being used in attempts to create similar structure in some ceramic materials in anticipation that the resulting complex will be stronger than conventional ceramics alone.

CONCLUSION

We reemphasize that while native mussels have been valuable to us in the past and they are currently, it is likely their future worth will be even greater. While we have provided only a few examples, we believe the point is made that mussels and other obscure organisms that many may think of as relatively worthless, may hold the answers to questions in fields as diverse as medicine, agriculture, and manufacturing--some which have not yet been asked. Unfortunately, negative human impacts from factors such as habitat alterations and destruction, and pollution, combined with what appears to be over exploitation, have reduced our native mussel populations over time. And zebra mussels and navigation expansion are additional and significant threats to their future. As a result, the benefits we will derive from this natural resource, both currently and in the future, may be only a fraction of what might be realized if we were able to better protect and even enhance our native mussel communities. To do this, we need to be aware that management decisions based on cost-benefit analyses which totally ignore ecosystem services and the potential value of new knowledge will not adequately protect organisms such as our freshwater mussels of the Illinois River. Our challenge is to do what we can to insure organisms such as freshwater mussels persist, to be diligent and imaginative both in our management efforts and our research to understand these organism, and to apply that knowledge to solving problems.

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13. ABSTRACT (Maximum 200 words)

The historical importance of mussels to humans is well documented at archeological sites throughout the Illinois River Valley. Native Americans used mussels for food and their shells for tools and ornaments. Early settlers harvested mussels for the infrequent but highly prized pearls they yielded. Beginning about 1891, mussels were used as the raw material for the pearl button industry, which became a multi-million-dollar industry in the United .States by 1899. With the advent of plastics, the pearl button industry died out by the late fifties, but in the sixties, the development of techniques for culturing pearls provided a new market for mussel shells. Today their shells are harvested from Midwestern rivers and exported to Japan, the current center of the cultured pearl industry. Reports submitted to the Illinois Department of Natural Resources indicate that in Illinois, annual sales of shells harvested from the Illinois and Mississippi Rivers averaged about 970 tons per year from 1963 through 1995, with the maximum reported harvest of 1963 tons in 1985. In 1996, shellers received an average of $1.70/pound for these shells. Today, freshwater mussels are one of the most endangered groups of organisms. Of 297 taxa described for North America, 213 (72%) are considered extinct, endangered, threatened, or of special concern. Management of our mussel resources is impeded by our incomplete knowledge about these complex organisms. They have a complicated life cycle which necessitates a fish host for completion of its larval stage. Field studies to better understand the life history and ecology of mussels often are confounded by impacts of navigation, habitat alterations, pollution, and harvest. Such investigations often require the use diving which is laborious, expensive, and can be dangerous. The preservation and enhancement of our mussel resources, the services they perform, and their economic values are dependent upon the development and implementation of sound, science-based management strategies. Without increased efforts to understand and protect these organisms, their future is questionable

14. SUBJECT TERMS

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